RSTP – IEEE 802.1w (Rapid Spanning Tree Protocol)

Cabrillo College

CIS 187 Multilayer Switched Networks

CCNP 3 version 4

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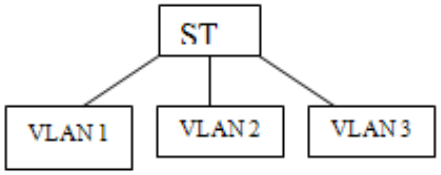
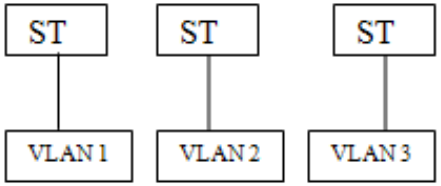
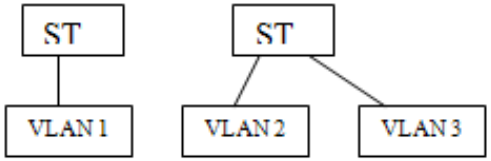
Fall 2006

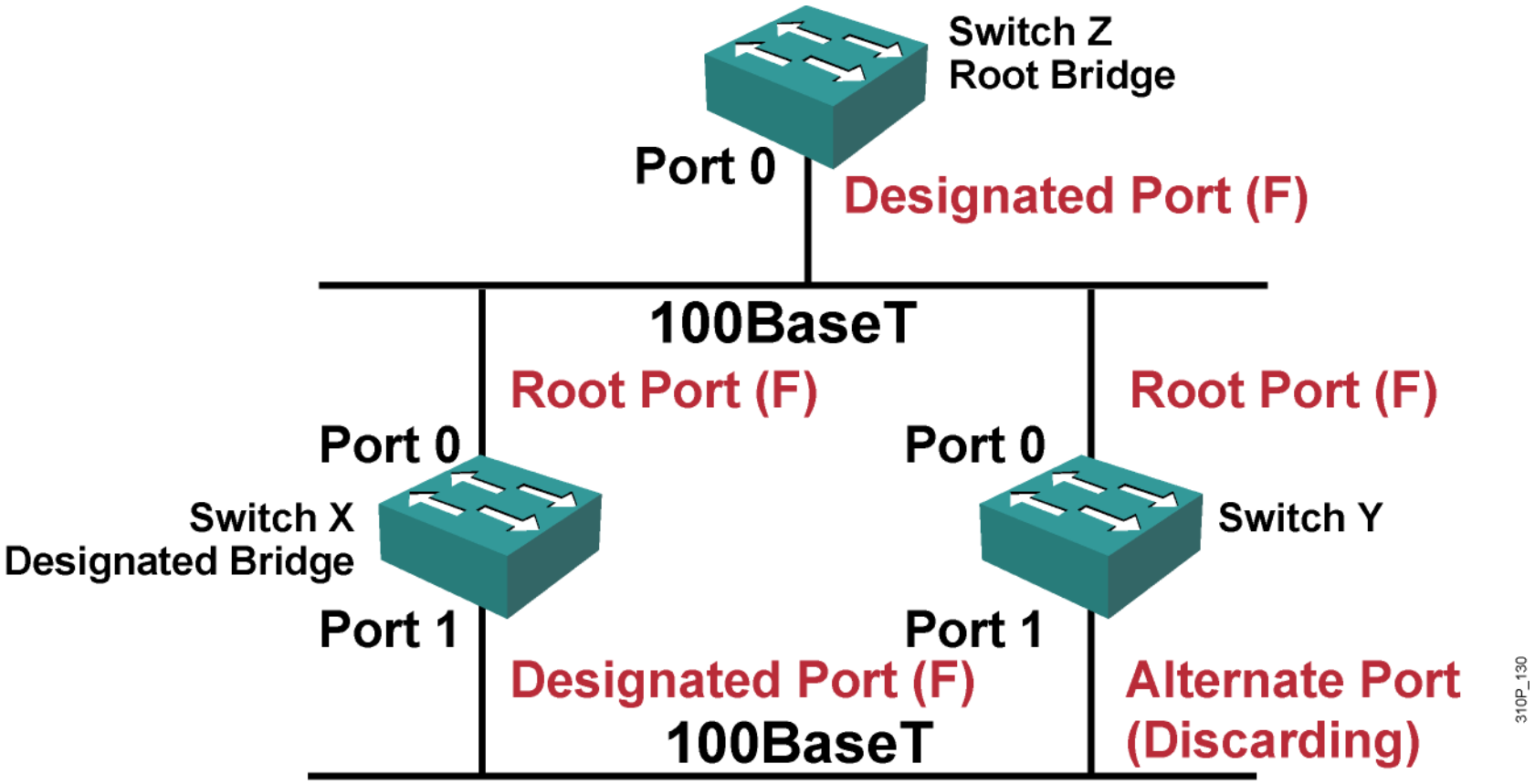
Evolution of STP

Cisco's Implementation	Spanning Tree Protocol Process	IEEE Standard
Spanning Tree Protocol (STP): • 802.1D • Common Spanning Tree (CST) • Mono Spanning Tree (MST)	ST = Spanning Tree 	
Cisco Enhancements (First evolution): • Portfast • Uplinkfast • Backbonefast		RSTP: • 802.1w • Edge Fast (Cisco Port Fast) • Uplink Fast RSTP (Cisco Uplink Fast) • Backbone Fast Engine (Cisco Backbone Fast)

Cisco Enhancements (Second Evolution):
• PVST: ISL
• PVST+: ISL & 802.1Q
• Includes previous enhancements
• Additional enhancements:
  ○ BPDU Guard
  ○ Root Guard
		

Cisco MISTP: • Uses PVST+ • Includes previous enhancements • Catalyst 4000/6000		MST (Multiple Spanning Tree): • 802.1s • Uses RSTP

Rapid Spanning Tree Protocol



Rapid Spanning Tree Protocol

- The immediate hindrance of STP is convergence.
- Depending on the type of failure, it takes anywhere from 30 to 50 seconds, to converge the network.
- RSTP helps with convergence issues that plague legacy STP.

RSTP vs STP

- RSTP is based on IEEE 802.1w standard.
- Numerous **differences** exist between RSTP and STP.
- RSTP requires full-duplex point-to-point connection between adjacent switches to achieve fast convergence.
  - Half duplex, denotes a shared medium, multiple devices.
  - As a result, RSTP cannot achieve fast convergence in half-duplex mode.
- STP and RSTP also have **port designation differences**.
  - RSTP has **alternate** and **backup** port designations.
  - Ports not participating in spanning tree are known as **edge ports**.
  - The edge port becomes a **nonedge port** immediately if a BPDU is heard on the port.
- TCNs
  - Nonedge ports participate in the spanning tree algorithm; hence, only nonedge ports generate Topology Changes (TCs) on the network when transitioning to forwarding state only. TCs are not generated for any other RSTP states.
  - In legacy STP, TCNs were generated for any active port that was not configured for PortFast.

RSTP vs STP

- RSTP is proactive and therefore negates the need for the 802.1D delay timers.
- RSTP (802.1w) supersedes 802.1D, while still remaining backward compatible.
- RSTP BPDU format is the same as the IEEE 802.1D BPDU format, except that the Version field is set to 2 to indicate RSTP.
- The RSTP spanning tree algorithm (STA) elects a root bridge in exactly the same way as 802.1D elects a root.

RSTP vs STP

- However, there are critical differences that make RSTP the preferred protocol for preventing Layer 2 loops in a switched network environment.
- Many of the differences stem from the Cisco proprietary enhancements.
- The Cisco-based RSTP enhancements have these characteristics:
  - They are integrated into the protocol at a low level.
  - They are transparent.
  - They require no additional configuration.
  - They generally perform better than the Cisco-proprietary 802.1D enhancements.
  - BPDU carries information about port roles and is sent to neighbor switches only.
- Because the RSTP and the Cisco-proprietary enhancements are functionally similar, features such as UplinkFast and BackboneFast are not compatible with RSTP.

RSTP Port States

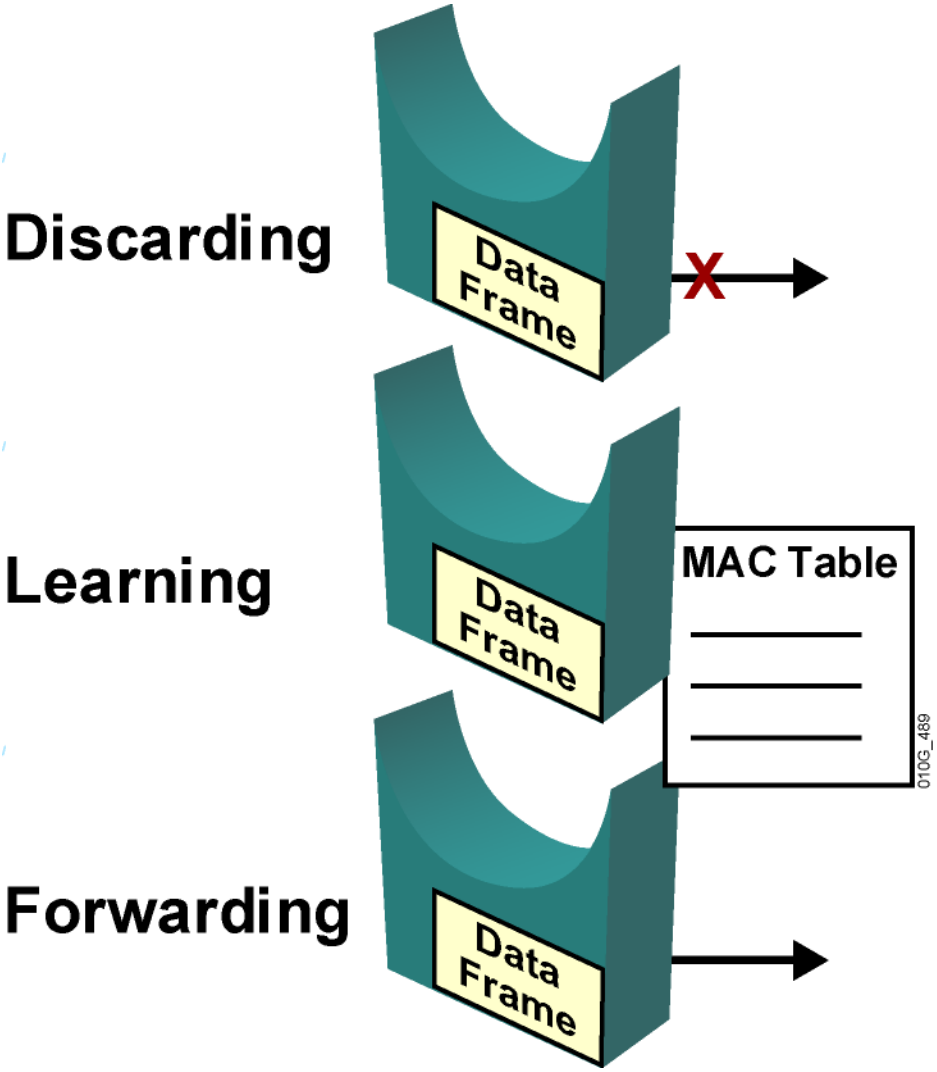
Port State	Description
Discarding	•This state is seen in both a stable **active topology and during topology synchronization** and changes. •The discarding state **prevents the forwarding of data frames**, thus "breaking" the continuity of a Layer 2 loop.
Learning	•This state is seen in both a stable **active topology and during topology synchronization** and changes. •The learning state **accepts data frames to populate the MAC table** in an effort to limit flooding of unknown unicast frames.
Forwarding	•This state is seen **only in stable active topologies**. •The **forwarding** switch ports determine the topology. • Following a topology change, or during synchronization, the forwarding of data frames occurs only after a proposal and agreement process.

Port States

The table describes STP and RSTP port states.

Operational Port State	STP Port State	RSTP Port State
Enabled	Blocking	Discarding
Enabled	Listening	Discarding
Enabled	Learning	Learning
Enabled	Forwarding	Forwarding
Disabled	Disabled	Discarding

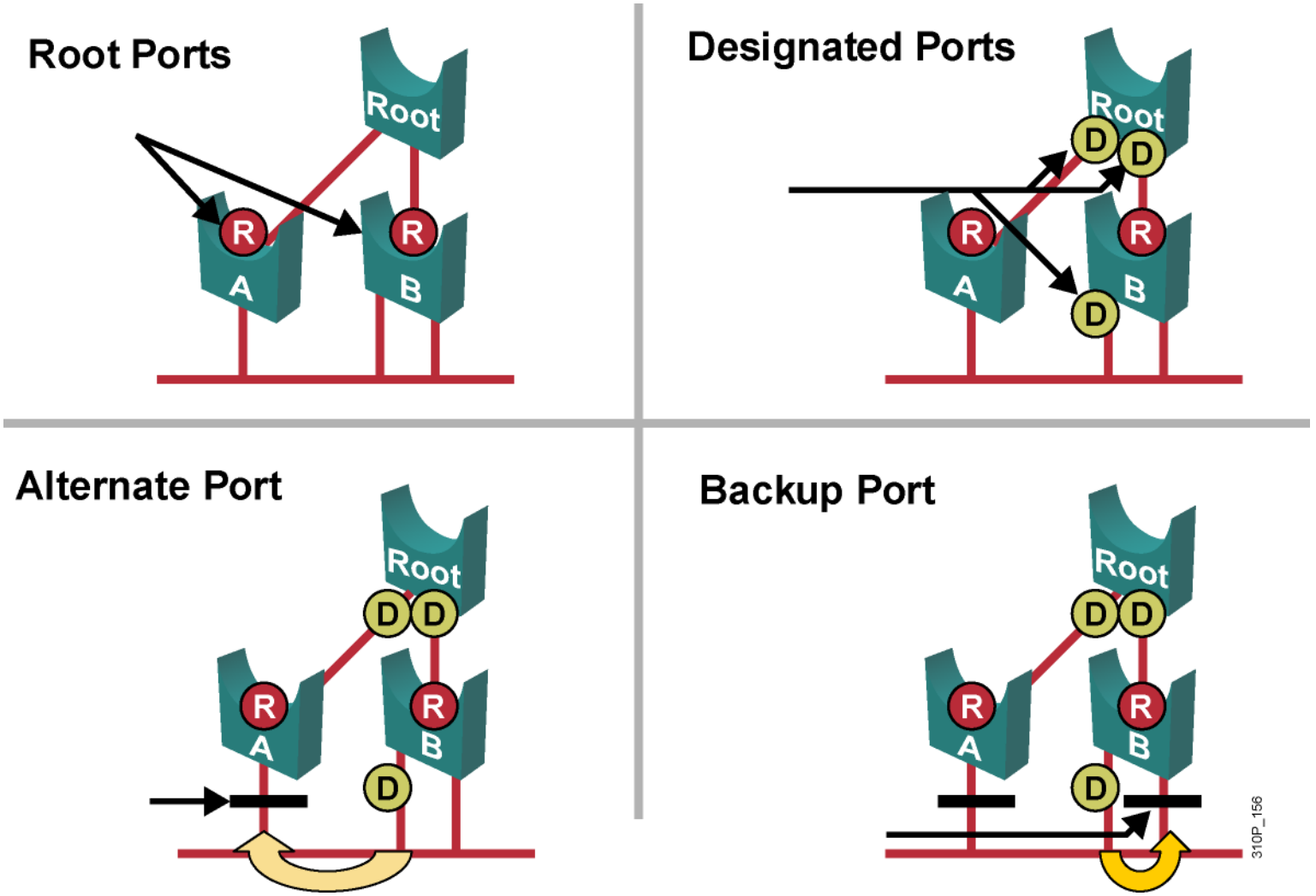
RSTP Port States



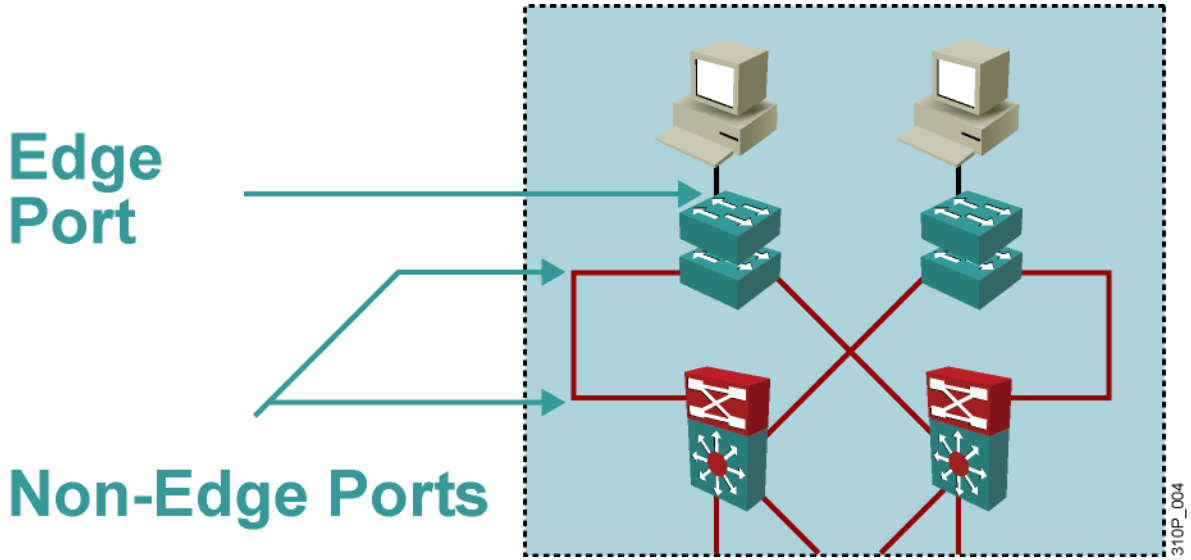
Port Roles

Port Role	Description
Root port (Same as STP)	The root port is the switch port on every nonroot bridge that is the chosen path to the root bridge. There can be only one root port on every switch. The root port assumes the forwarding state in a stable active topology.
Designated port (Same as STP)	Each segment has at least one switch port as the designated port for that segment. In a stable, active topology, the switch with the designated port receives frames on the segment that are destined for the root bridge. There can be only one designated port per segment. The designated port assumes the forwarding state. All switches connected to a given segment listen to all BPDUs and determine the switch that will be the designated switch for a particular segment.
Alternative port (Non-Designated Port in STP)	The alternative port is a switch port that offers an alternative path toward the root bridge. The alternative port assumes a discarding state in a stable, active topology. An alternative port is present on nondesignated switches and makes a transition to a designated port if the current designated path fails.
Backup port	The backup port is an additional switch port on the designated switch with a redundant link to the segment for which the switch is designated. A backup port has a higher port ID than the designated port on the designated switch. The backup port assumes the discarding state in a stable, active topology.

RSTP Port Roles



What Are Edge Ports?

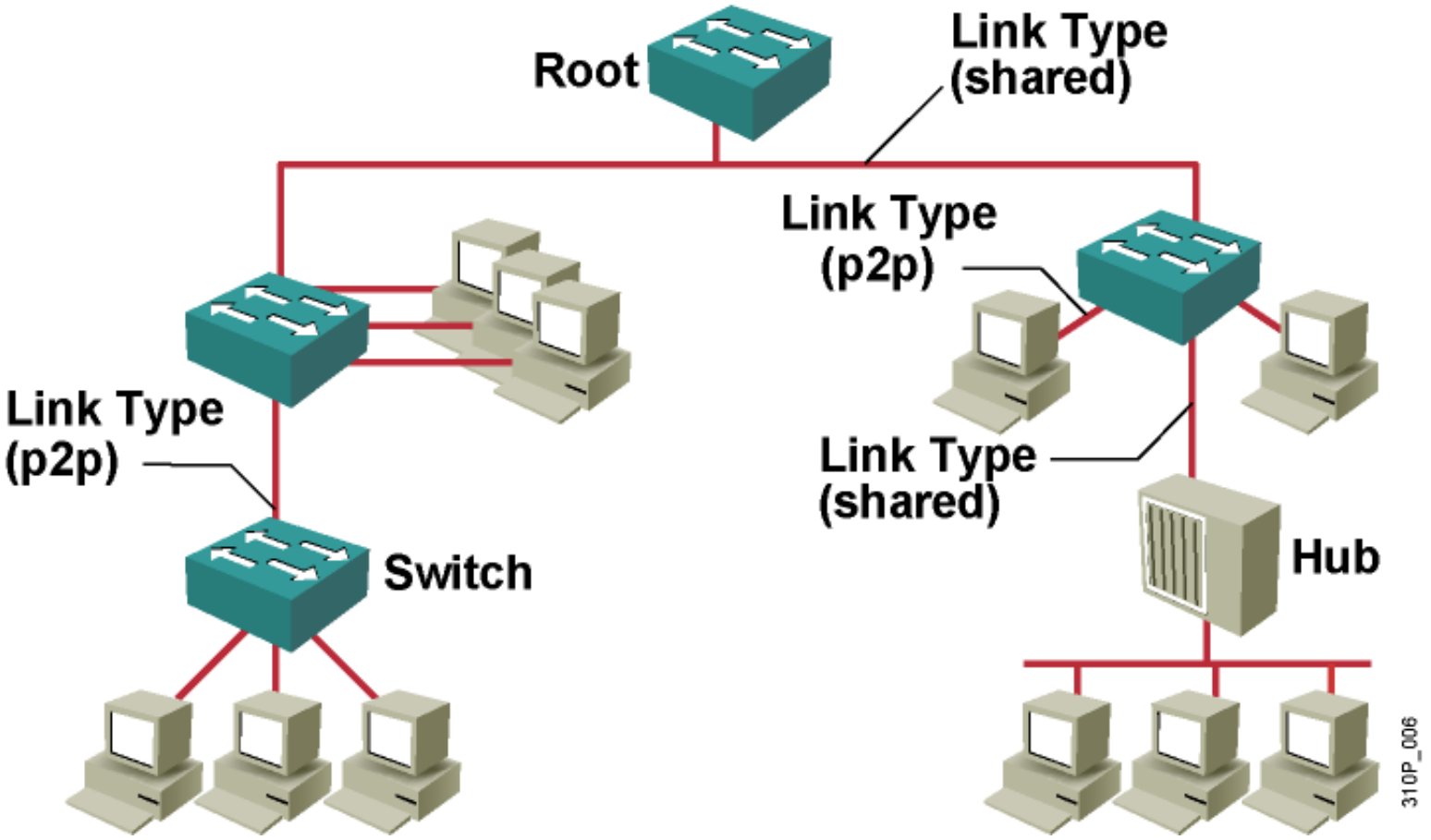


- **Will never have a switch connected to it**
- **Immediately transitions to forwarding**
- **Functions similarly to PortFast**
- **Configured by issuing the** spanning-tree portfast **command**

Edge Ports

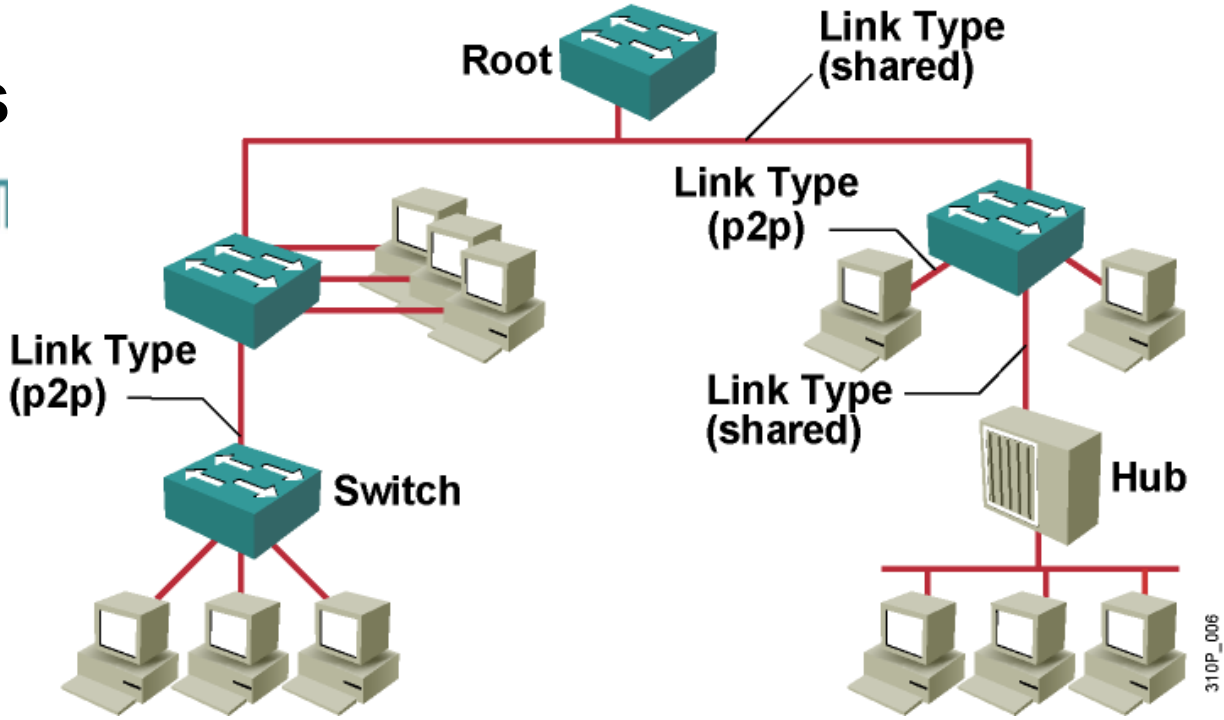
- An RSTP edge port is a **switch port that is never intended to be connected to another switch device**.
- It immediately transitions to the forwarding state when enabled.
- The edge port to the **PortFast feature**.
- All ports directly connected to end stations anticipate that no switch device will be connected to them and immediately transition to the STP forwarding state, thereby skipping the time-consuming listening and learning stages.
- **Unlike PortFast**, an edge port that ***receives a BPDU*** immediately loses its edge port status and ***becomes a normal spanning tree port***.
  - **Portfast**
  - If a switch is connected to the interface when PortFast is enabled, temporary bridging loops can occur.
  - When the BPDU guard feature is enabled on the switch, STP shuts down PortFast enabled interfaces that receive BPDUs instead of putting them into a blocking state.
- Cisco's RSTP implementation maintains the PortFast keyword for edge port configuration, thus making an overall network transition to RSTP more seamless.

RSTP Link Types



RSTP Link Types

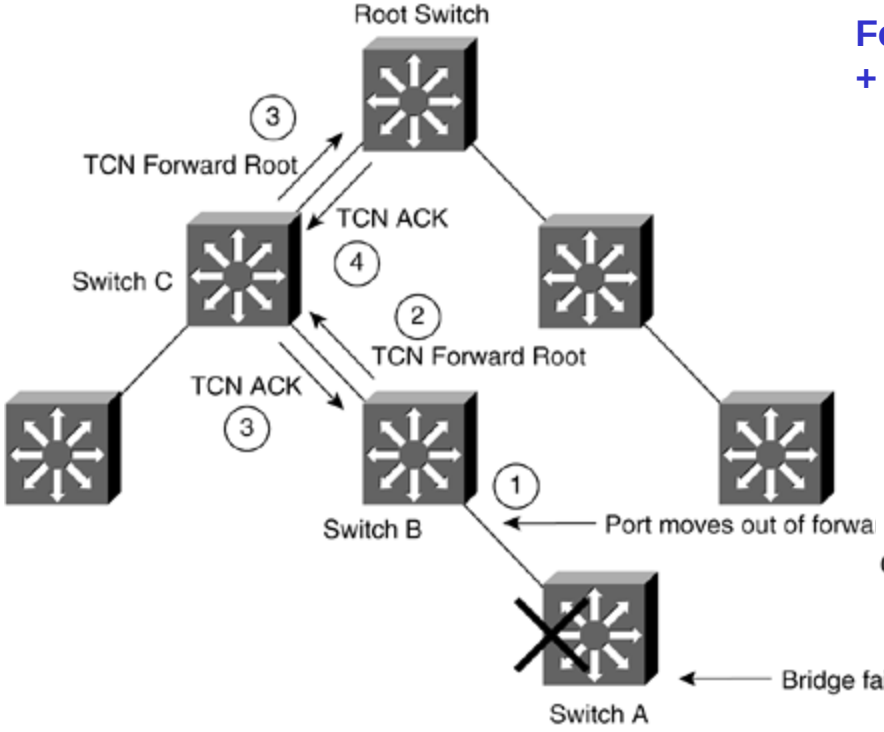
- The link type can predetermine the active role that the port plays as it stands by for immediate transition to a forwarding state, if certain parameters are met.
- These parameters are different for **edge ports** and **non-edge ports**.
- **Non-edge ports** are categorized into two link types.
- Link type is automatically determined but can be overwritten with an explicit port configuration.

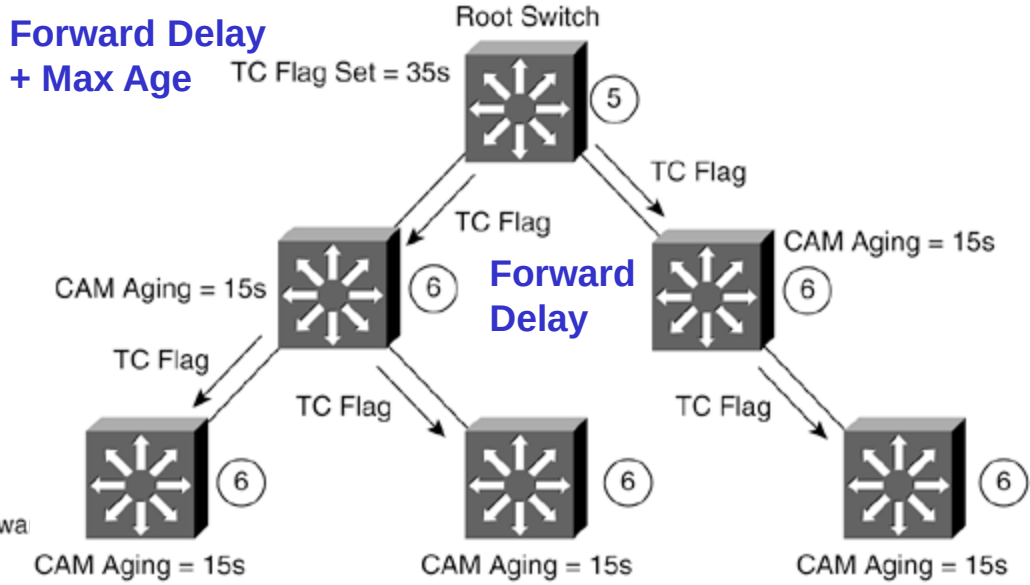


RSTP Link Types

Link Type	Description
Point-to-point	•Port operating in full-duplex mode. •It is assumed that the port is connected to a single switch device at the other end of the link.
Shared	•Port operating in half-duplex mode. •It is assumed that the port is connected to shared media where multiple switches might exist.

Topology Changes: STP and RSTP



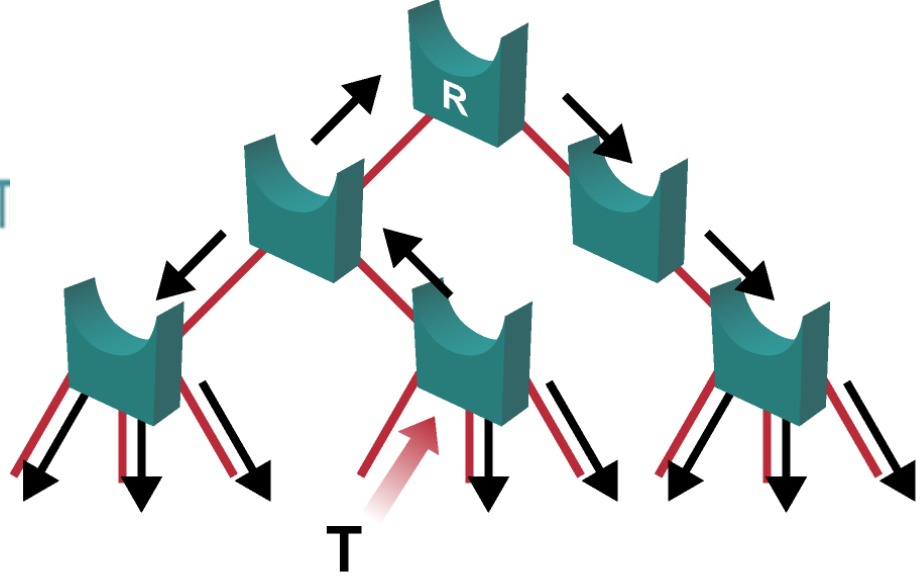


- In **802.1D**, any port state change generates a **TCN**.
- When an 802.1D bridge detects a topology change (TC), it sends TCNs toward the root bridge.
- The root bridge sends out a TC (Configuration BPDUs) that are relayed to switches down from the root.
- When a bridge receives this BPDU the switch reduces its bridge-table aging time to **forward delay** seconds.
  - It does not wait the 5 minutes (300 seconds) to age ot the MAC Address table.
- This ensures a ***relatively quick flushing*** of the **MAC address table**.

RSTP Topology Change Mechanism

Initiator floods network with change instead of communicating with Root and having Root to it.

Switches to not wait for 15 seconds (Forward Delay) or 35 seconds (Root: Max age + Forward Delay)



The originator of the TC directly floods this information through the network.

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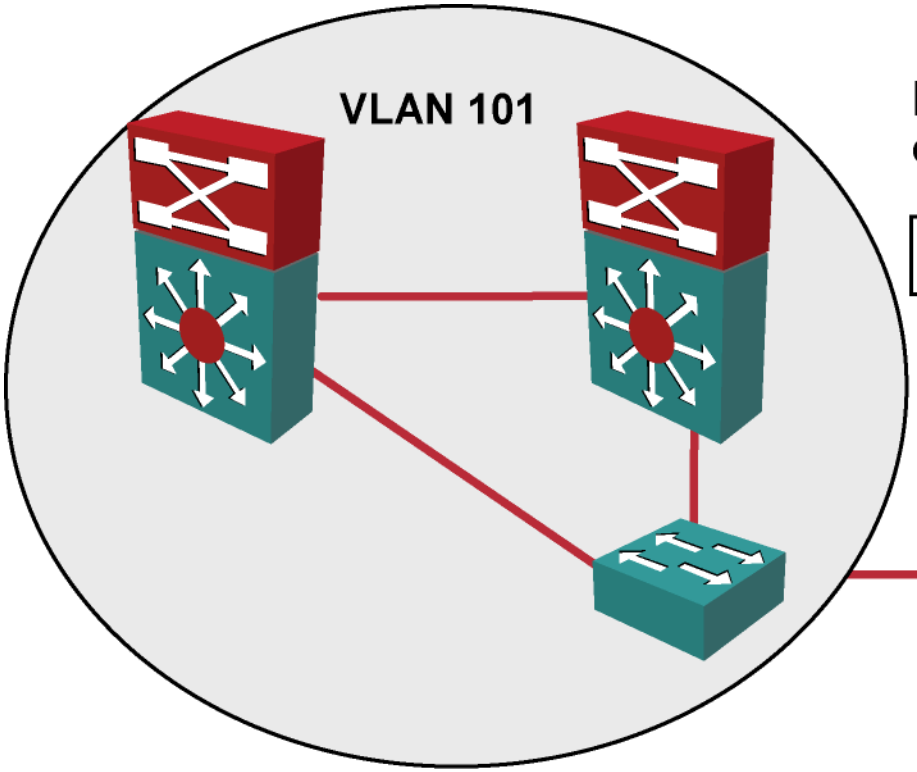
- In RSTP, **only non-edge ports moving to the forwarding state** cause a topology change.
- Loss of connectivity is not considered to be a topology change, and, under these conditions, a port moving to the blocking state does not generate a TC BDPU.
- Switches clear MAC Address tables and move to forwarding almost immediately (TC While timer).
- The topology change propagation is now a one-step process.
- The initiator of the topology change is flooding this information throughout the network, as opposed to 802.1D, where it relies on the root.
- This mechanism is much faster than the 802.1D equivalent.

Rapid PVST Implementation Commands

- Configuring
  - **spanning-tree mode rapid-pvst**
- Verifying
  - **show spanning-tree vlan 101**
- Debugging
  - **debug spanning-tree**

How to Implement Rapid PVST

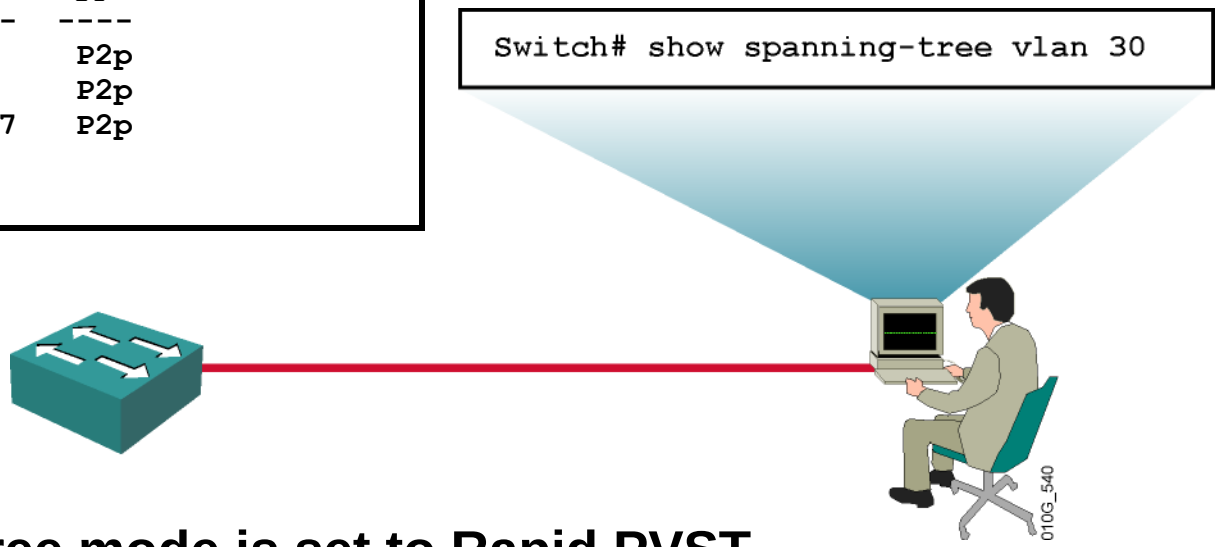


Rapid RSTP is implemented on all switches in the VLAN.

```
Switch(config)# spanning-tree mode rapid-pvst
```

Verifying Rapid PVST


```
Switch# show spanning-tree vlan 30
VLAN0030
Spanning tree enabled protocol rstp
Root ID Priority 24606
Address 00d0.047b.2800
This bridge is the root
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Bridge ID Priority 24606 (priority 24576 sys-id-ext
30)
Address 00d0.047b.2800
Hello Time 2 sec Max Age 20 sec Forward Delay 15 sec
Aging Time 300
Interface Role Sts Cost Prio.Nbr  Type
-------- ----- --- ---  --------  ----
Gi1/1     Desg FWD  4    128.1     P2p
Gi1/2     Desg FWD  4    128.2     P2p
Gi5/1     Desg FWD  4    128.257   P2p
```

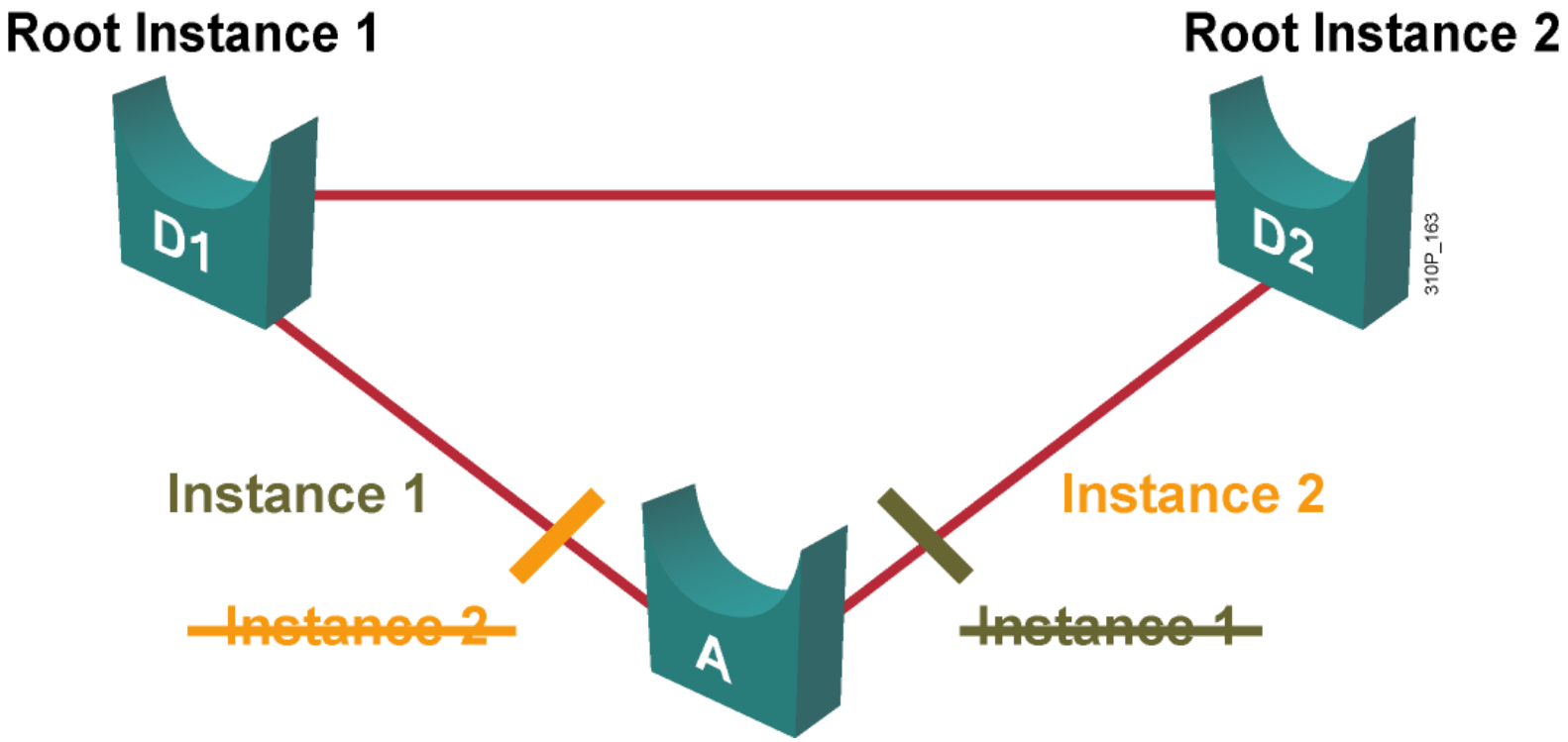


Display spanning tree mode is set to Rapid PVST.

RSTP Summary

- RSTP provides faster convergence than 802.1D STP when topology changes occur.
- RSTP defines three port states: discarding, listening, and forwarding.
- RSTP defines five port roles: root, designated, alternate, backup, and disabled.
- Edge ports forward while topology changes occur.
- RSTP makes use of two link types – p2p and shared.
- The RSTP topology change notification process differs from 802.1D.
- Rapid PVST enables RSTP while still maintaining PVST.

Multiple Spanning Tree Protocol – 802.1s



Instance 1 maps to VLANs 1–500
Instance 2 maps to VLANs 501–1000

Multiple Spanning Tree Protocol – 802.1s

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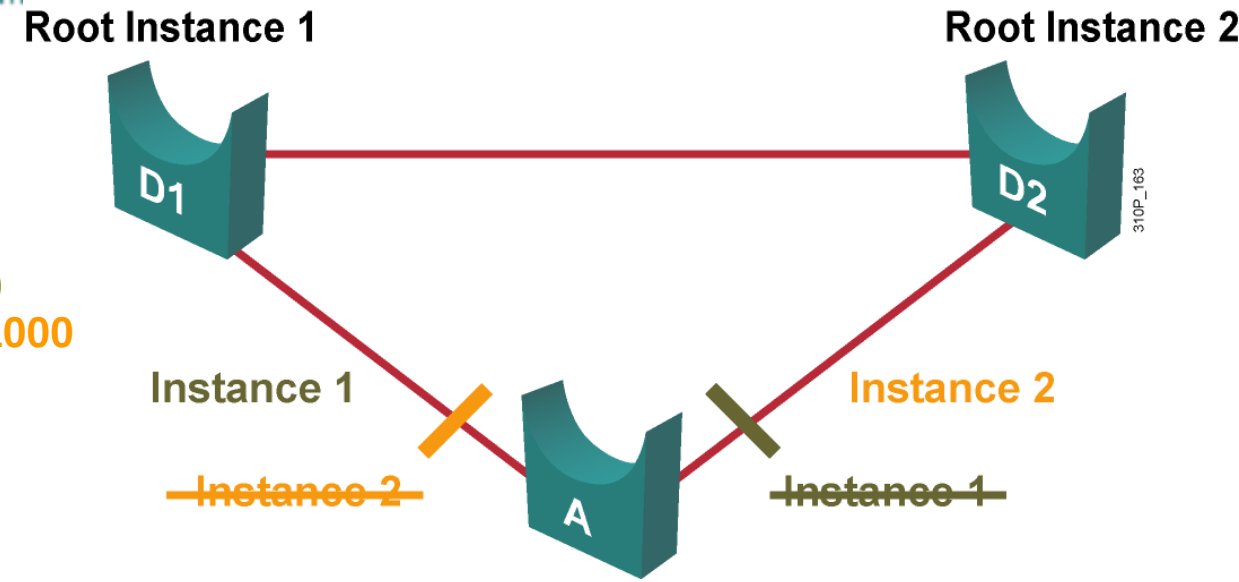
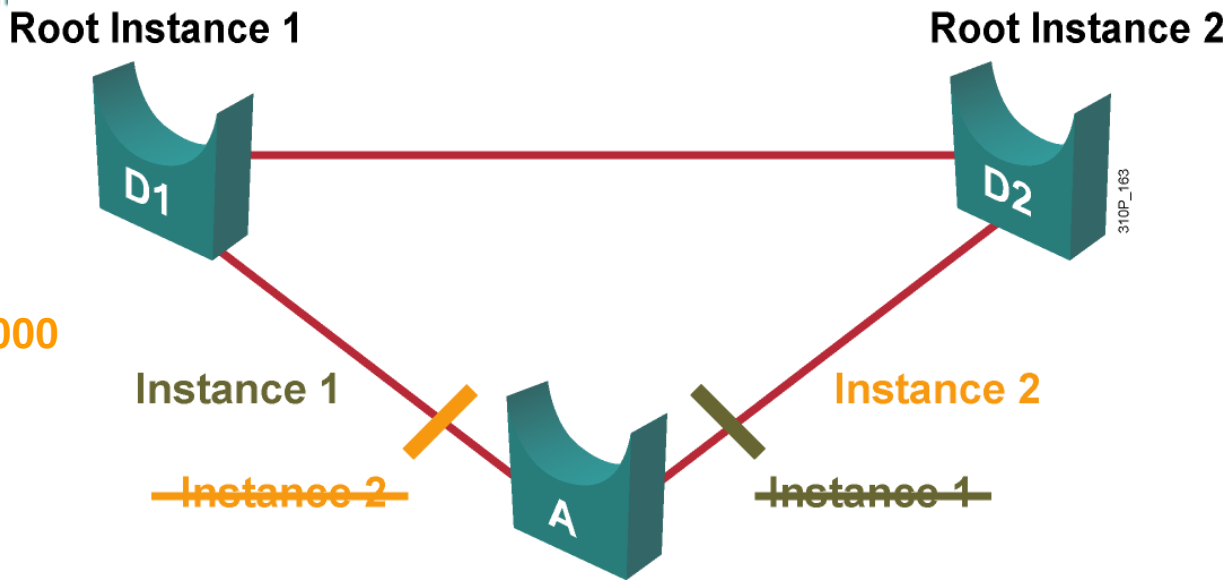


- **Multiple Spanning Tree (MST)** extends the IEEE 802.1w RST algorithm to multiple spanning trees.
- The main purpose of MST is to **reduce the total number of spanning-tree instances to match the physical topology of the network** and thus reduce the CPU cycles of a switch.
- **PVST+** runs **STP instances for each VLAN and does not take into consideration the physical topology** that may not require many different STP topologies.
- **MST**, on the other hand, uses a **minimum number of STP instances** to match the number of physical topologies present.

Multiple Spanning Tree Protocol – 802.1s

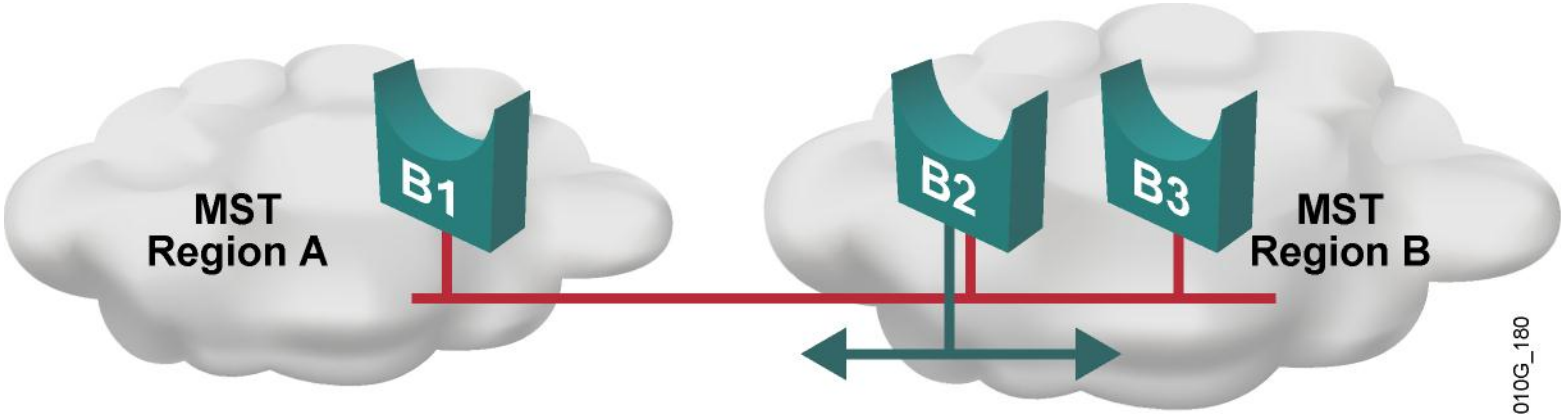


Instance 1 maps to VLANs 1–500
Instance 2 maps to VLANs 501–1000

- The 1000 VLANs map to two MST instances.
- Rather than maintaining 1000 spanning trees (like PVST+), each switch needs to maintain only **two spanning trees**, reducing the need for switch resources.

MST Regions

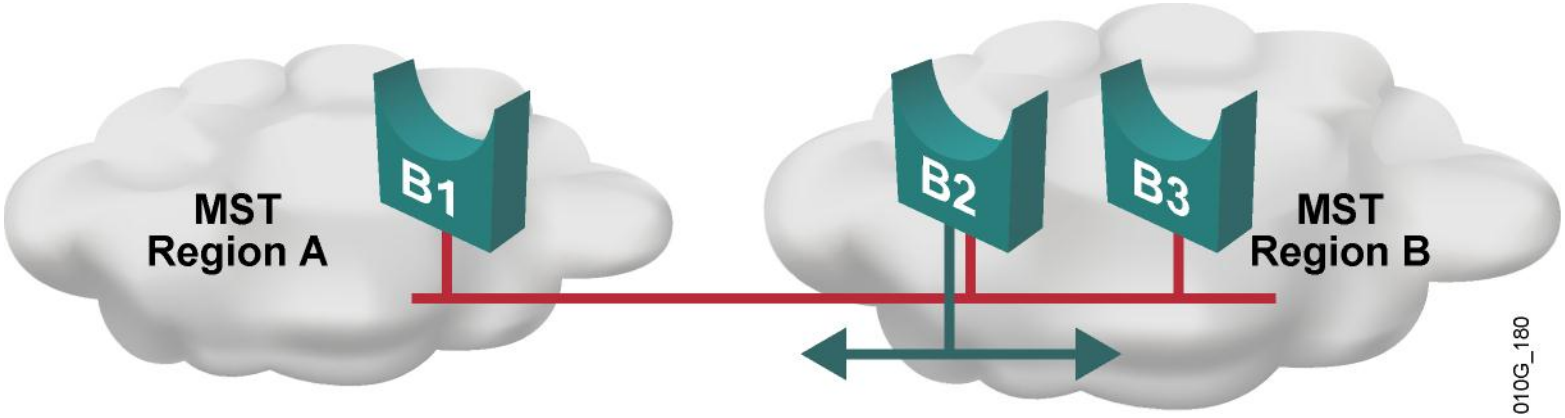
Received BPDU = Which VLANs is this associated with?



- The main enhancement introduced by MST is the ability to map several VLANs to a single spanning-tree instance.
- This raises the problem, however, of determining what VLAN is to be associated with what instance.
  - Based on **received BPDUs**, devices need to **identify these instances and their VLANs** (VLANs that are mapped to the instances).

MST Regions

Received BPDU = Which VLANs is this associated with?



- *Details not important…*
- Each switch that is running MST in the network has a single MST configuration that consists of three attributes:
  - An alphanumeric configuration **name** (32 bytes)
  - A configuration **revision number** (2 bytes)
  - A 4096-element **table** that associates each of the **potential 4096 VLANs** supported on the chassis to a given instance

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